Control Theory for SRE

Using PID Controllers to scale your services smoothly
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Control Theory For SRE
History of Control Theory

- What is a PID controller? Why use one?
- Steam Engines and Centrifugal Governors
- Cruise Control in your Car
- Ship Steering
Centrifugal Governor - Ealiest application.

A Centrifugal Governor (https://en.wikipedia.org/wiki/Centrifugal_governor) is one of the earliest examples of a PID controller.
"The possibility of obtaining more accurate steering by automatic means than can be accomplished by manual control with its inherent limitation due to the low sensitiveness of the human eye in detecting slow angular motions, fatigue, etc., becomes of greater importance with the increase in size of ships and cost of fuel"

- N. Minorsky, Directional Stability of Automatically Steered Bodies, May 1922
Math of a PID controller

Error at time $t$:

$$e(t) = SP - PV$$

$$u(t) = K_p e(t) + K_i \int_0^t e(t') \, dt' + K_d \frac{de(t)}{dt},$$

Diagram from https://en.wikipedia.org/wiki/PID_controller#Mathematical_form
PID Math in Prometheus

- record: control_terms_kp
  expr: avg(control_kp) * pid2d_error

- record: control_terms_ki
  expr: avg(control_ki) * sum_over_time(pid2d_error[10m])

- record: control_terms_kd
  # The d term is extrapolated out to the same window as the Ki term
  expr: avg(control_kd) * idelta(pid2d_error[1m]) * count_over_time(pid2d_error[10m])
PID Math in Prometheus

- record: pid2d_location
  expr: (pid2d_location + pid2d_velocity) or vector(0)
- record: pid2d_error
  expr: avg(control_setpoint) - pid2d_location

- record: pid2d_deltav
  expr: clamp_min(clamp_max((control_terms_kp + control_terms_ki + control_terms_kd), 100), -100)
- record: pid2d_velocity
  expr: (pid2d_velocity + pid2d_deltav) or vector(0)
Introducing the technologies

- Prometheus
- Grafana
- Controller
- Kubernetes
Demo - A simple PID Controller.
Tuning a PID controller

- Hand tuning
  
  (https://en.wikipedia.org/wiki/Ziegler%E2%80%93Nichols_method)

- Damping

- Other methods
About this talk

The source for this presentation can be found at gitlab.com/gauntletwizard/pid-controller-talk

The presentation itself is available online at pidtalk.kube.gauntletwizard.net/presentation.slide

Areas for further work:
- Add more explanation to this repository
- Build a Kuberenets Model
References:


Thank you

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